Inconstancy: An Ontology Repair Plan for Adding Hidden Variables

Inconstancy: An ontology repair plan for adding hidden variables

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Outline

1. Overview
2. "Inconstancy"
3. Examples
   - MOdified Newtonian Dynamics (MOND)
   - Boyle's Law
4. Discussion

Ontology repair plans

Ontology repair needed for changing environment

- Not just changes to *beliefs*, but to *signatures* as well
- Atomic operations: split functions, add arguments, etc.

The "Inconstancy" ontology repair plan

- Triggered by conflict between predicted independence and observed dependence
- Apply to two historical repairs in physics
- Implemented in λProlog (GALILEO - *Guided Analyses of Logical Inconsistencies Lead to Evolved Ontologies*)

The "Inconstancy" ontology repair plan

Trigger

$$
\begin{array}{rcl}
O_t & \vdash & stuff(\vec{x}) ::= c(\vec{x}) \\
O_s(V(\vec{s}, \vec{b_1}) = v_1) & \vdash & stuff(\vec{s}) = c_1(\vec{s}), \ldots \\
O_s(V(\vec{s}, \vec{b_n}) = v_n) & \vdash & stuff(\vec{s}) = c_n(\vec{s}), \\
\exists i \neq j. O_t & \vdash & c_i(\vec{s}) \neq c_j(\vec{s})
\end{array}
$$

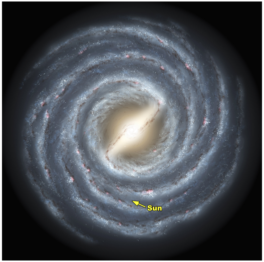
Add variad

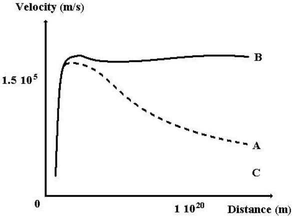
$$\nu(stuff) ::= \lambda \vec{y}, \vec{x}.\ F(c(\vec{x}), V(\vec{x}, \vec{y}))$$

Create new axioms

$$
\begin{array}{rcl}
Ax(\nu(O_t)) & ::= & \{\phi\{stuff/\nu(stuff)(\vec{y})\} \mid \phi \in Ax(O_t) \setminus \\
 & & \{stuff(\vec{x}) ::= c(\vec{x})\}\} \cup \\
 & & \{\nu(stuff) ::= \lambda \vec{y}, \vec{x}.\ F(c(\vec{x}), V(\vec{x}, \vec{y}))\} \\
Ax(\nu(O_s(V(\vec{s}, \vec{b_i}) = v_i))) & ::= & \{\phi\{stuff/\nu(stuff)(\vec{b_i})\} \mid \phi \in Ax(O_s(V(\vec{s}, \vec{b_i}) = v_i))\}
\end{array}
$$

MOdified Newtonian Dynamics (MOND)





- Newtonian theory of gravity predicted that objects further out will have lower velocities
- The observed velocities of those objects are almost constant!
- MOND - The gravitational force ($F = \frac{G \times M \times m}{r^2}$) is different at low accelerations.

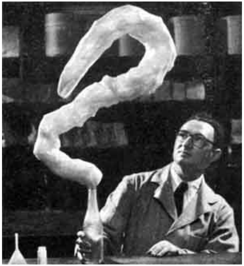
Application to MOND

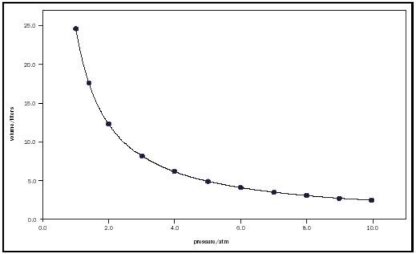
Example

$$\begin{array}{rcl}
O_t & \vdash & G ::= 6.67 \times 10^{-11} \\
O_s(Acc(S_1) = A_1) & \vdash & G = M2OV^{-1}(OV(S_1), Mass(S_1), \\
 & & \lambda s \in Spiral \setminus \{S_1\}.\ (Posn(s), Mass(s)))\ (= G_1) \\
\vdots & & \vdots \\
O_s(Acc(S_n) = A_n) & \vdash & G = M2OV^{-1}(OV(S_n), Mass(S_n), \\
 & & \lambda s \in Spiral \setminus \{S_n\}.\ (Posn(s), Mass(s)))\ (= G_n) \\
\exists i \neq j.\ O_t & \vdash & G_i \neq G_j
\end{array}$$

$$\begin{array}{rcl}
\nu(O_t) & \vdash & \nu(G) ::= \lambda s.F(6.67 \times 10^{-11}, Acc(s)) \\
\nu(O_s(Acc(S_1) = A_1)) & \vdash & \nu(G)(S_1) = M2OV^{-1}(OV(S_1), Mass(S_1), \\
 & & \lambda s \in Spiral \setminus \{S_1\}.\ (Posn(s), Mass(s)))\ (= G_1) \\
\vdots & & \vdots \\
\nu(O_s(Acc(S_n) = A_n)) & \vdash & \nu(G)(S_n) = M2OV^{-1}(OV(S_n), Mass(S_n), \\
 & & \lambda s \in Spiral \setminus \{S_n\}.\ (Posn(s), Mass(s)))\ (= G_n)
\end{array}$$

Boyle's Law





- Boyle's law states that, at a fixed temperature, the pressure and the volume of a gas are inversely proportional, i.e. $pressure \times volume = k$
- The ideal gas law: $pressure \times volume = k \times temperature$

Application to Boyle's Law

Example

$$
\begin{array}{rcl}
O_t & \vdash & Boyle(gas) ::= \lambda mom.\ P(gas, mom) \times V(gas, mom) = K(gas) \\
O_s(T(Gas, Mom_1) = T_1) & \vdash & Boyle(Gas) = P(Gas, Mom_1) \times V(Gas, Mom_1)\ (= K_1) \\
\vdots & & \vdots \\
O_s(T(Gas, Mom_n) = T_n) & \vdash & Boyle(Gas) = P(Gas, Mom_n) \times V(Gas, Mom_n)\ (= K_n) \\
\exists i \neq j.\ O_t & \vdash & K_i \neq K_j \\
\hline
\nu(O_t) & \vdash & \nu(Boyle) ::= \lambda mom, gas.\ F(K(gas), T(gas, mom)) \\
\nu(O_s(T(Gas, Mom_1) = T_1)) & \vdash & (\nu(Boyle)(Mom_1))(Gas) = P(Gas, Mom_1) \times V(Gas, Mom_1)\ (= K_1) \\
\vdots & & \vdots \\
\nu(O_s(T(Gas, Mom_n) = T_n)) & \vdash & (\nu(Boyle)(Mom_n))(Gas) = P(Gas, Mom_n) \times V(Gas, Mom_1)\ (= K_n)
\end{array}
$$

Conservativity

"Inconstancy" is a conservative extension if:

- The definition of *stuff* remains

...Create new axioms

$$
\begin{aligned}
Ax(\nu(O_s(V(\vec{s},\vec{b_i}) = v_i))) \quad &::= \quad \{\phi\{stuff/\nu(stuff)(\vec{b_i})\} \mid \phi \in Ax(O_s(V(\vec{s},\vec{b_i}) = v_i))\} \\
Ax(\nu(O_t)) \quad &::= \quad \{\phi\{stuff/\nu(stuff)(\vec{y})\} \mid \phi \in Ax(O_t) \setminus \\
&\qquad \{stuff(\vec{x}) ::= c(\vec{x})\}\} \cup \\
&\qquad \{\nu(stuff) ::= \lambda\vec{y},\vec{x}.\ F(c(\vec{x}), V(\vec{x},\vec{y}))\}
\end{aligned}
$$

- The ontology setup enables conservatitvity to be achieved

Conservativity is not guaranteed

Problems solved by adding arguments

Unexpected variation

- Add the parameters (variad) causing variation
- Approximate the new function by regression
  - MOND: $F(6.67 \times 10^{-11}, Acc(s))$ returns 6.67×10^{-11} or a value proportional to $Acc(s)^2 \times Rad(s)^2$, depending on $Acc(s)$
  - Boyle's Law: $F \equiv \times$ (as required by the ideal gas law!)

Problems solved by adding arguments

Argument specialisation

- Refine arguments

Example

$$O_t \vdash SpecHeat(o, t) = k \text{ (specific heat of } o \text{ at } t\text{)}$$

($SpecHeat(o, t)$ is $Temp(o, t)$ used in the latent heat example)

- *SpecHeat* is too abstract
- We know the specific heat of an object is: heat capacity $\times$ mass $\times$ difference in temperature ($=cm\Delta T$)

$$\nu(O_t) \vdash \nu(SpecHeat)(CapConst(o), Mass(o), Tmpt(o, t)) = k$$

- Again, approximate the new function by regression
- $\nu(SpecHeat(o, t)) \equiv \times$

Summary

The "Inconstancy" ontology repair plan:

- Triggered by conflict between predicted independence and observed dependence
- Introduce a new function relating the constancy with the variad
- Approximate the new function using regression
- Implemented in Terzo and Teyjus (λProlog) - GALILEO
- Other suggested repairs?

Questions?